

Photovoltaic plant at Jungfrauoch

Christof Bucher, Matthias Burri

Bern University of Applied Sciences, PV Laboratory, Burgdorf, Switzerland

christof.bucher@bfh.ch

Keywords: photovoltaics; PV system; PV module

1. Project description

In 1993, the highest grid connected PV plant in the World was built at Jungfrauoch (3454 meters above sea level) [1]. Since then, the 24 modules Siemens M75 (48Wp) with a total rated power of 1152 Wp reliably produced solar electricity. The PV module degradation has found to be 0.11% per year in former publications [2], which is roughly ten times less than predicted based on typical degradation warranties at the time. Until today, the PV system is used to monitor the long-term performance of PV technology.

2. Activities 2022

In 2022, the BFH had two major activities on Jungfrauoch: First, novel algorithms for data evaluation optimised for non-complete data sets have been developed and tested. Second, a new data base based on Influx has been set up and established.

2.1 Data Evaluation

Long data series of outdoor measurements are normally neither error-free nor complete. Therefore it is necessary to apply suitable algorithms for outlier and gross error detection.

In a paper published at the World PV Conference in Milano [3], Latifa El Boujdaini has presented several filtering algorithms for the long term measurement data of BFH. She compared the influence of the filter settings on the primary key performance index for PV systems, which is the performance ratio PR.

Using only energy yield data harvested while the irradiance is between 700 W/m² and 900 W/m², degradation rates shown in Figure 1 have been found. Thereby it can be seen, that the degradation rate for Jungfrauoch is found to be 0.02% per year, which is even less than stated in previous publications [2].

In order to characterise the stability of PV module parameters over time, the degradation rates are calculated for data measured at certain temperatures and irradiances only. A three dimensional plot showing degradation as a function of the data filter is shown in Figure 2.

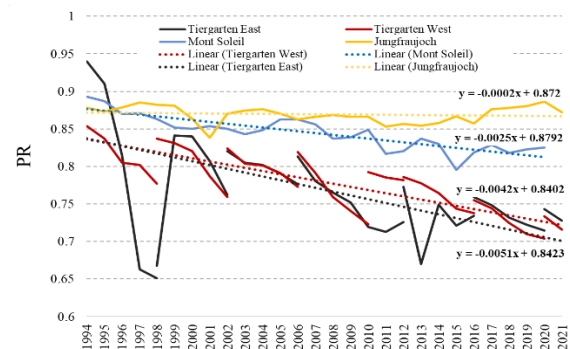


Figure 1. Linear degradation rates found at the PV systems Jungfrauoch, Mont-Soleil and Tiergarten Burgdorf.

While in Burgdorf a clear correlation between temperature, irradiance and degradation can be seen (less degradation if lower temperatures and irradiances are being respected only), the same effect on Jungfrauoch is less clear. In Burgdorf, looking at low temperatures and low irradiance only, the degradation is less than looking at high irradiance and temperature. On Jungfrauoch, this effect cannot be confirmed.

Yet it can be confirmed that the PV module degradation is much less on Jungfrauoch than in Burgdorf. As Jungfrauoch sees higher irradiance (which is one stress factor for a PV module) but lower temperatures, it can be assumed that the higher temperatures in Burgdorf are the main cause for the degradation.

In a further investigation, the linearity of the degradation was questioned in Figure 3. Based on a second order polynomial fit, it can be seen that the performance ratio was slightly higher when the system was new, but recovered in the past few years. This phenomena cannot be explained yet and will be further investigated in future.

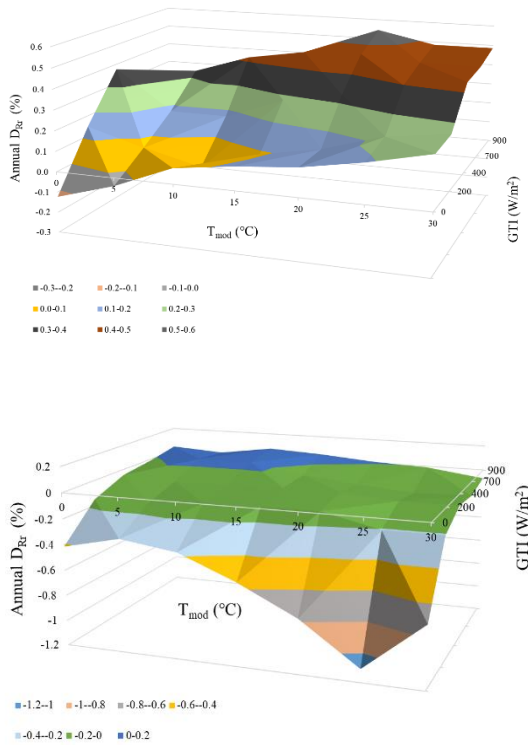


Figure 2. Annual degradation rates depending on the filter settings for temperature and irradiance GTI (top: Burgdorf Tiergarten West, bottom Jungfrauoch).

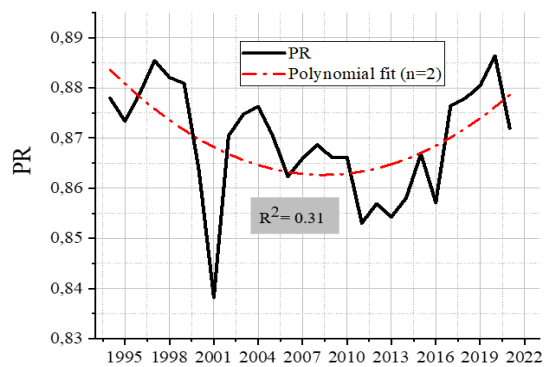


Figure 3. Fitting a square function to the Performance Ratio curve on Jungfrauoch.

2.1 New Database

Until 2021, the data of all PV systems of the BFH PV Lab was collected in a data base using import and export software which was developed at BFH. As this software was complex and expensive to maintain, a new software solution based on

InfluxDB and Telegraf interface was tested and introduced. In 2023, the reliability of this new software solution will be tested. This should increase the efficiency of future data evaluation projects.



Figure 4. PV system at Jungfrauoch

References

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Address

Bern University of Applied Sciences BFH
 Dept. Engineering and Information Technology (EIT)
 Photovoltaic Laboratory (PV LAB)
 CH-3400 Burgdorf
 Switzerland

Contacts

Prof. Dr. Christof Bucher
 Tel.: +41 34 426 69 08
 e-mail: christof.bucher@bfh.